GMI 2006

Validating IMS: The Practical Implementation of Converged Networks

MultiService Forum

Executive Summary

Global MSF Interoperability 2006 (GMI 2006) represents the first international, multivendor validation of IMS (IP-based Multimedia Services), the underlying framework that will enable the long-heralded, long-awaited Next-Generation Network (NGN)—as well as the array of advanced services that these converged networks will deliver.

This in and of itself is a remarkable accomplishment. What makes GMI 2006 even more significant is that it validates the core capabilities of IMS: unrestricted roaming across multiple network types, with consistent services- and without performance penalties.

More specifically, unrestricted roaming allows subscribers and devices to access the network from anywhere, eliminating the boundaries that once separated fixed, mobile, and wireless networks. This is the essence of Fixed-Mobile Convergence (FMC): Subscribers can initiate a session on, for example, a wireless LAN (WLAN) at work, and receive the same service set they would receive across the cellular infrastructure or from their home office.
Equally important, IMS ensures that this unfettered movement neither disrupts nor degrades the Quality of Service (QoS) of whatever value-added service a subscriber is using. Finally, IMS supports true multimedia services, which can range from Voice over IP (VoIP) and text messaging through streaming audio and videoconferencing—to name a few possibilities.

In addition to evaluating this essential aspect of IMS, GMI 2006 also validated the MultiService Forum (MSF) Architecture Release 3 as a full peer network to a "pure" IMS implementation. This demonstrates the ability of vendors whose products comply with all relevant MSF Implementation Agreements (IAs) to interoperate in this environment.

GMI 2006 also demonstrated:

- Effective and enforceable QoS using Session Border Controller (SBC) and Bandwidth Manager (BM)
- IP Carrier interconnect/interworking
- Security interoperability in an FMC environment
- Third-party applications and service brokering
- Interworking of priority calling between PSTN and NGN

About GMI 2006

GMI 2006, the global MSF Interoperability event, was the culmination of some 12 months preparation. It was conducted over 12 days, from October 16 through October 27, at major carrier and independent labs worldwide that were networked together for this event.

Five of the world's top carriers—BT, KT, NTT, Verizon and Vodafone—along with world-class testing and research facilities at the University of New Hampshire Interoperability Lab (IOL) and ETRI, joined together to host this major event, sponsored by Nortel. A total of 27 vendors participated.

With a unique global network connecting labs on three continents, GMI 2006 was in effect the first massive "real network" trial of the MSF Release 3 architecture announced on September 12th. MSF R3 is the first industry specification to describe physical implementations of IMS (IP Multimedia System)-enabled devices in real-world deployment scenarios that explicitly include first-generation VoIP SoftSwitches, PSTN interworking, and evolution to a true IMS network.

Three months or more were typically required to prepare a host site to carry out the extensive test program mandated by the MSF. During the event, engineers at each site typically worked an average of 14 hours a day, although longer days were not unusual. The event provided world-class networked test facilities spanning three continents and bringing together dozens of carriers and vendors in a massive 'real network' trial to validate MSF Release 3 Implementation Agreements covering a wide range of topics including roaming across multiple network types (including cellular and WiFi), QoS issues (including session border control and bandwidth management), and interoperability with 3GPP release 4.

GMI 2006: The Industry Impact

GMI 2006 is not the first evaluation of IMS. A number of vendors have performed IMS interoperability testing in their labs, with selected partners. There also have been interoperability events that have focused on specific services or protocols. These efforts have been valuable- and have moved the industry forward and contributed to the overall confidence in IMS.

Several things set GMI 2006 apart from these earlier efforts. This initiative represents the first multinational, multivendor interoperability test of IMS. "The breadth of the GMI process, particularly the end-to-end global validation, is one of the most significant aspects of GMI," says Roger Ward, Office of the CTO, BT Group, and President of the MSF. "Unlike other, more limited tests, GMI 2006 doesn't stop at the service interface. It assesses actual service delivery."

Most importantly, by evaluating the end-to-end operation of IMS networks and services, GMI 2006 demonstrates that IMS is ready for real-world networks now. This is critical to carriers and vendors concerned with practical deployment and interoperability. "Interoperability is the key to the transition to IMS," explains Ward. "In practice, carriers have networks at various stages of IMS and NGN implementation. We see networks with a mix of legacy infrastructure and pure IMS gear, and a broad array of multivendor equipment. The MSF and its GMI validations are concerned with practical, real-world considerations and explicitly address the heterogeneous environment that exists in carrier networks today."

Ward continues, "We use commercially available equipment, deployed in realistic network configurations, to prove the maturity of emerging technologies based on MSF IAs." GMI 2006 presents a realistic assessment of what is available and what remains to be done, to make fully converged IP-based networking a reality.

MSF members find that GMI 2006 is a tremendous source of information for engineering and product development. The data gathered by GMI 2006 is equally valuable to standards bodies, helping them evaluate and refine emerging specifications. One of the most important roles of the MSF is to complement the work of standards bodies by addressing practical implementation issues and providing feedback to standards bodies based on the interoperability testing conducted in GMI.

GMI 2006 was an unqualified success, validating the overall MSF Release 3 Architecture. Specific issues were uncovered, and this information will be used to help improve MSF IAs and refine future testing. Further, as a "dress rehearsal" for the deployment of IMS, GMI 2006 provided valuable insight, indicating what works well and revealing where more still needs to be done. In addition, key conclusions from GMI 2006 will be forwarded to the Standards Development Organizations (SDOs) responsible for the standards at the core of IMS, allowing these standards to be refined where appropriate.

GMI 2006 By the Numbers

An event as ambitious as GMI 2006 requires an enormous commitment of personnel and other resources from all participants. To give a sense of the scope of GMI 2006, a total of 27 vendors deployed equipment at five host sites in four countries on three continents. The testing was conducted by over 200 engineers at the GMI host sites. For every engineer at one of the five host sites, there were additional engineers supporting them from their company labs. This brought the total number involved in GMI 2006 to well over 500 engineers.

The test plans for GMI 2006 encompassed the core IAs defined for the MSF R3 architecture. This resulted in a test suite that was too large to complete in a two-week event, but provided the flexibility to quickly narrow the scope during the actual test event to match the equipment in each lab and the time available. In fact, 200 pieces of equipment were brought to test at GMI 2006, and over two-thirds of the test plans were required to fully test it all.

Table 1: GMI Tests Cases

Scenario	Total Test Cases	Test Cases Not Tested	Percent of Scenario Tested
Scenario 0a	1	0	100
Scenario 1	25	7	72
Scenario 1a	39	1	97
Scenario 2	33	12	64
Scenario 3	7	2	71
Scenario 4	9	0	100
Scenario 5	22	7	68
Total	136	29	

Note: an additional Scenario, Scenario 0, had 10 test cases, but these involved initial steps verifying the network and equipment configurations. Thus they were passed implicitly as a part of preparing for the remaining scenarios.

The GMI 2006 test suite comprised 150 test cases that were used as the basis for 350 test runs applied to seven test scenarios. The simplest scenario involved a subscriber within a single domain; the most complex, a subscriber accessing value-added services while roaming across several IMS/MSF R3 domains. The 150 tests in the GMI 2006 test suite covered 21 MSF IAs, 19 of which have been introduced and finalized since GMI 2004.

Getting a sense of the human scale of GMI 2006, also helps underscore its accomplishments. As noted, tests were conducted over 12 days, from October 16 through October 27—although three months or more were typically required to prepare a host site for the actual evaluations. Engineers at each host site typically worked 14 hours a day, although longer days were not unusual. For example, Ken Mills Office of the CTO, BT Group and UK GMI 2006 Host Site Manager, who was in charge of the test network at the BT host site, notes that while the normal day started at 8:00 a.m. and wrapped up at 10:00 p.m., there were some nights when the engineers and test staff were still hard at it at 1:00 a.m.

Mills offers a few other salient observations. The key to successful testing on this scale is preparation, preparation, and more preparation. It won't stop things from going awry—after all the intent of GMI is to stress the MSF Implementation Agreements to the breaking point. However, preparation will ensure that mistakes are easy to identify and resolve. One challenge is that the test network itself, due to its temporary nature, can prove surprisingly fragile. This fragility can be exacerbated by the constant reconfiguration to implement the next test scenario or substitute vendor equipment. This subjects the test network to a level of fluidity that a live network would never experience without extensive acceptance testing.

The payback for the participants is the satisfaction of seeing issues resolved and scenarios completed successfully. "Testing," Mills explains, "to make sure what we've done is right" and identifying where a test went off track. Perhaps most satisfying of all, says Mills, was seeing competitors working together to solve problems, forgetting rivalries and "doing what engineers do."

"A lot of engineers," he continues, "don't get a chance to work together with engineers from other companies. But when we collectively solve common problems, that's good for the telecom industry." That statement also serves as an eloquent assessment of what GMI 2006 and the MSF are all about.

An Introduction to the MSF

The MSF is a global association of service providers, system suppliers and test equipment vendors committed to developing and promoting open-architecture, multiservice Next Generation Networks. Founded in 1998, the MSF is an open-membership organization whose members are drawn from the world's leading telecommunications companies. The MSF's activities include developing Implementation Agreements, promoting worldwide compatibility and interoperability of network elements, and encouraging input to appropriate national and international standards bodies.

MSF is a well-established forum with a balanced mix of carriers and vendors that integrates specific work from multiple standards into a holistic network and services architecture. The MSF architecture and solution framework combine legacy and next-generation services in a single unified network. Further, since all MSF participants implement the same baseline features and functions, members can eliminate the guesswork that technology development typically involves.

The advantages of MSF membership include:

- Access to more than eight years of groundbreaking industry work with input from key carriers and vendors
- The experience of some of the world's leading scientists and engineers
- The opportunity to leverage the external talent pool active in the MSF to more efficiently implement a validated architecture built on industry-standard protocols
- The ability to validate product implementations in industry-leading interoperability events

In addition, carriers and equipment vendors that actively participate in GMI events learn how multivendor next-generation products and networks will interoperate in the real world. That information translates into several financial benefits:

- Reduced time to market for deployment of interoperable solutions

- Decreased costs and resources to resolve interoperability issues

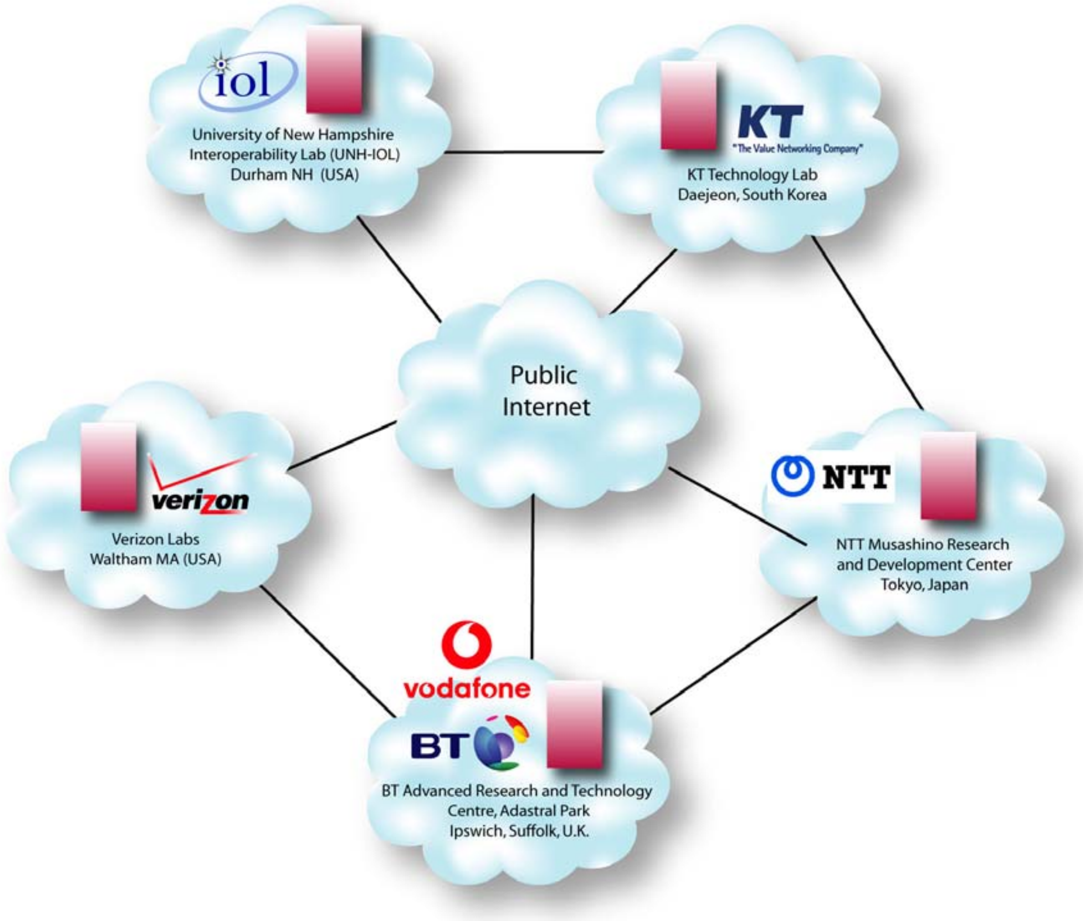
- Improved protocol documentation through clarifications in the MSF IAs and standards process

- Thoroughly evaluated architectural framework for cooperatively designing end-to-end networking solutions

Participants in GMI 2006

The MSF counts some of the leading global carriers, along with the telecom industry's top vendors, most exciting startups, and government telcom users among its members.

The GMI 2006 Network



IMS: A Quick Overview

Before digging into the details of the GMI 2006 test scenarios, it makes sense to take a quick look at IMS, particularly the basic assumptions involved and some of the key functions and interfaces it employs. This will help set the stage for a closer look at the test scenarios for GMI 2006.

IMS is a standardized framework for next-generation networking that supports fixed and mobile multimedia services. One of its core capabilities is unrestricted roaming, both for subscribers and devices. In other words, end-users must be able to access all services they subscribed to, regardless of their location. Further, subscribers have access to the same QoS, regardless of whether they access a service from a fixed network (for example, from home or from corporate HQ) or from a mobile network.

To attain this freedom and flexibility, IMS separates multimedia services from the underlying network; thus, the architecture is network-independent. To attain this independence, IMS defines a number of functions, which are linked by standardized interfaces. (A function isn't a node or a hardware component in the conventional sense. Service providers, telecom operators, and equipment vendors are free to combine functions in a single node.)

IMS call/session control is handled by SIP servers and proxies, which constitute what is collectively called the Call Session Control Function (CSCF). This function plays a key role in the GMI 2006 test scenarios. More specifically, three CSCF functions are employed:

- Proxy-CSCF (P-CSCF): Typically, this SIP server is the first point of contact for an IMS terminal. Among other responsibilities, the P-CSCF relays all SIP messages to and from the user, and establishes an IPsec association with the IMS terminal, which helps prevent spoofing attacks and protects subscriber privacy.

- Serving CSCF (S-CSCF): A SIP server that handles both signaling and session control. The S-CSCF downloads and uploads subscriber profiles, thus helping to ensure that QoS and performance parameters are met, regardless of where the end-user is located.

- Interrogating-CSCF (I-CSCF): A SIP server that retrieves the user location and then routes the SIP request to the correct S-CSCF. The I-CSCF also performs load balancing of user registrations across S-CSCF instances.

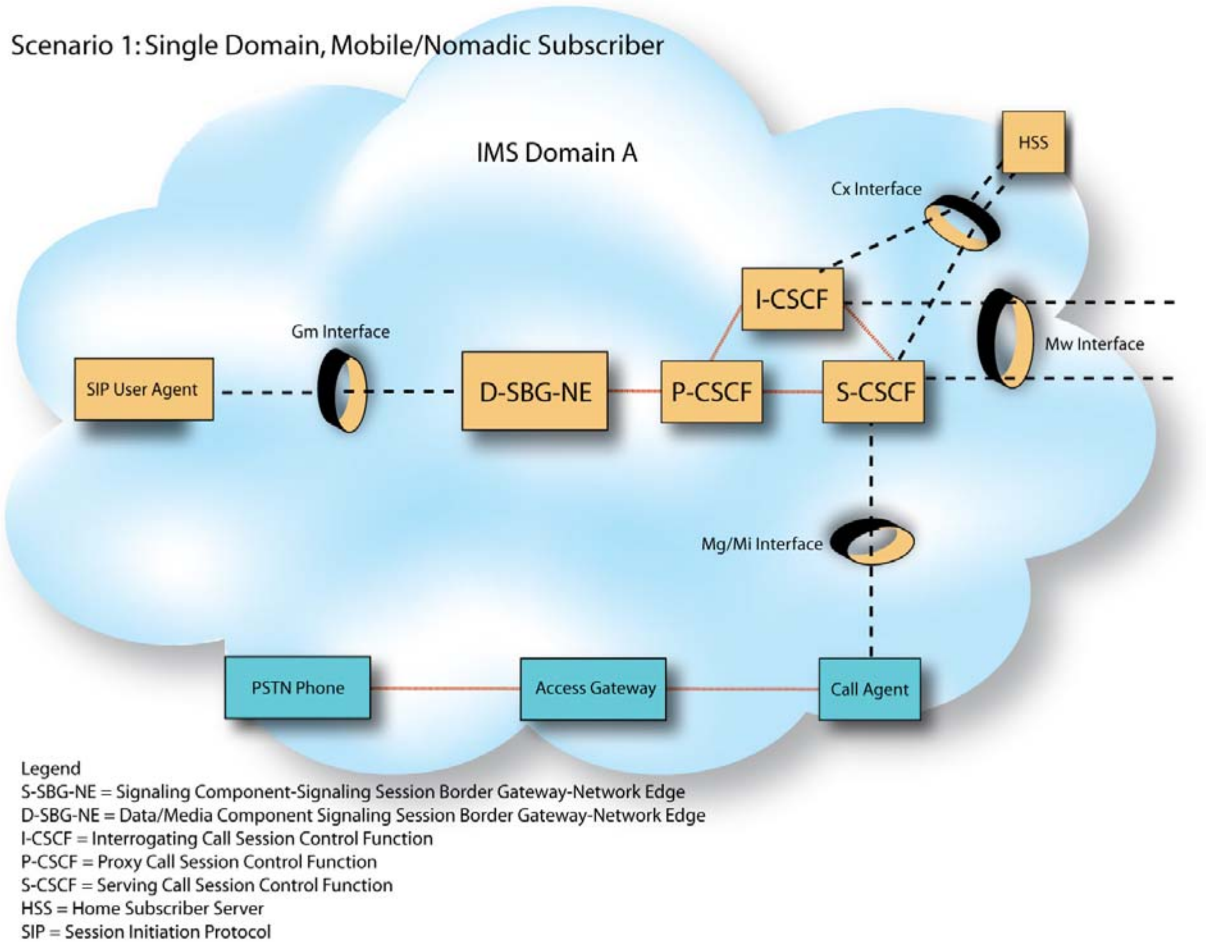
The IMS call control functions are supported by the Home Subscriber Server (HSS), the master subscriber database that is the key to implementing services that are independent of the underlying network. The HSS contains user profiles and information about the S-CSCF serving that user. It also plays a pivotal role in the authentication and authorization of end-users.

GMI 2006 Test Scenarios

Scenario 0/0a: Management of Basic GMI 2006 Connectivity

Scenario 0a validated the operation of the network management system for provisioning and testing the MPLS/VPN network. It verified the automatic calculation of optimum LSP (Label Switched Paths) and router configuration for MPLS/VPN provisioning based on RSVP-TE,and then confirmed that this configuration could be set up, modified, and deleted from a multi-vendor environment. Network topology information was calculated based on individual router configuration, and a full network traffic view was generated. Tests were then conducted to fully verify the initial setup of the network. The tests began with simple pings to establish routing connectivity, performed initial startup of MGCP, H.248, and Diameter sessions and then verified intra- and inter-domain call routing.

Scenario 1: Basic Call In Single IMS Domain



Scenario 1, which comprises a single IMS domain, serves as the basic building block for all of the GMI 2006 scenarios. This scenario validates the ability of an IMS device to register from various locations in the network, and to reach other devices, both IMS and non-IMS.

The MSF R3 architecture specifies that non-IMS devices, such as PSTN phones, can reach IMS subscribers by setting up a session using an access gateway and call agent. The call agent reaches the S-CSCF through the SIP Mg/Mj interfaces. The Mg interface passes calls from PSTN end points served by the call agent to the IMS network; the Mj interface passes calls in the reverse direction.

The SIP Gm interface passes call signaling between the UA and the P-CSCF.

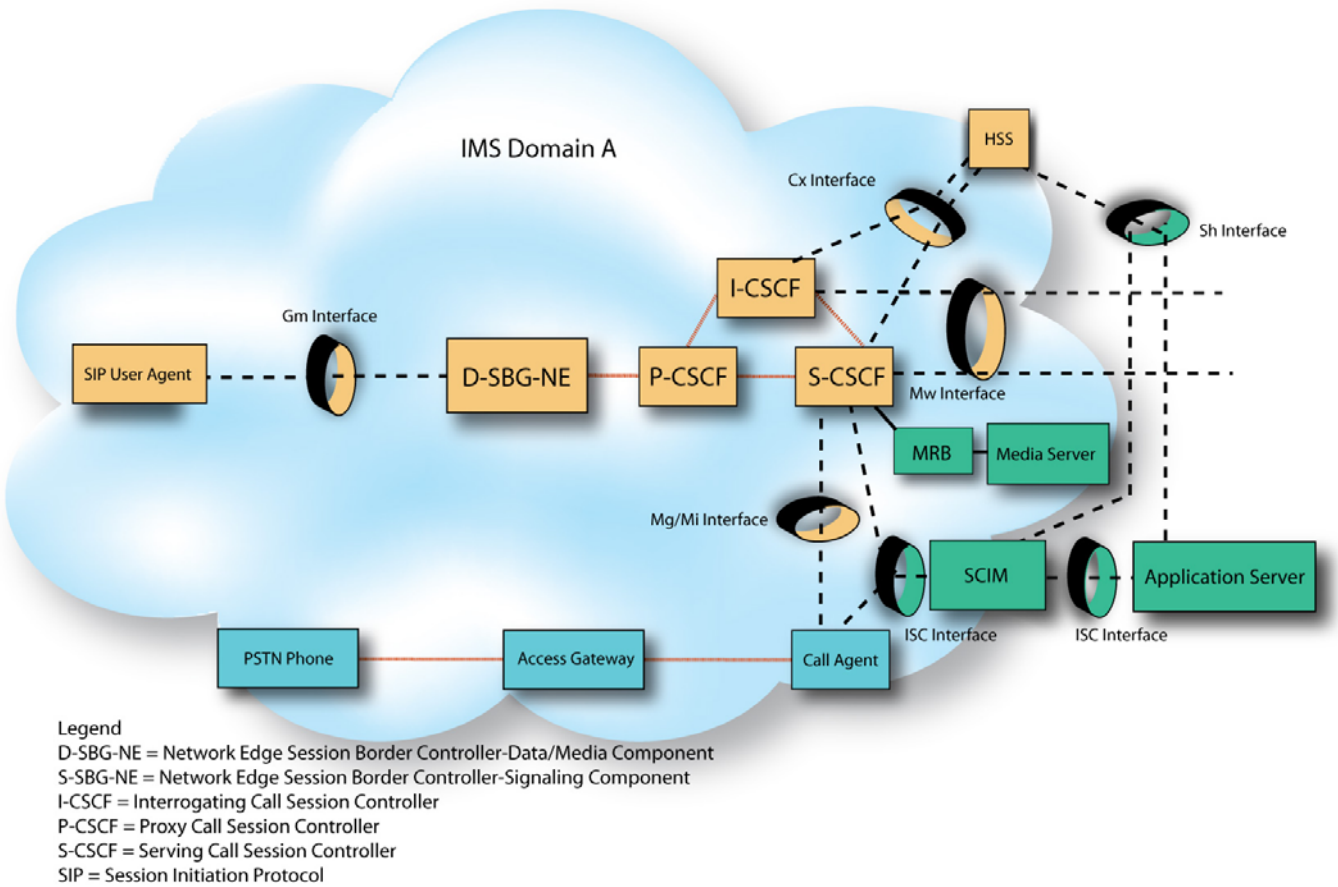
That takes care of getting the calls onto the IMS network. Finding the subscriber is a matter of accessing the Home Subscriber Server (HSS); this function contains the user profile, which includes S-CSCF instance for that user. The Cx interface communicates between the S-CSCF/I-CSCF and the HSS, so calls can be routed correctly.

Finally, the Mw interface is used to exchange information between CSCFs; in this case it acts like a NNI (Network-to-Network Interface), directing the call to the correct S-CSCF if it is located on another domain.

Scenario 1a: Mc Interface
This purpose of this scenario is validate the 3GPP Mc interface between the MSC-S and MGW in a 3GPP Release 4 Bearer Independent Core Network Architecture. The implementation of a BICN architecture enables transport of inter-MGW VoIP transport, independent scaling of MSC-Ss and MGWs throughout the network, and Transcoder Free Operation.
The messaging interaction on the Mc interface is verified in a number of functional capabilities: basic call establishment, call clearing, handover, general procedures, and so on.
It demonstrates the interoperability of the Mc Interface in a multivendor environment.

It should be noted that in order to fully focus on verifying the Mc Interface, other interfaces within the 3GPP BICN architecture are either eliminated from the test scenario (Nb: MGW to MGW, Nc: MSC-S to MSC-S) or simulated (radio interfaces).

Scenario 2: Single IMS Domain with Value-Added Services



The purpose of this scenario is to validate that a subscriber can access value-added services, such as priority voice and priority video sessions using third-party applications and caller ID suppression for user anonymity (originating identity restriction). Again, the subscriber can register from different points in the domain. As can be seen from the illustration, this capability requires several new functions and interfaces.

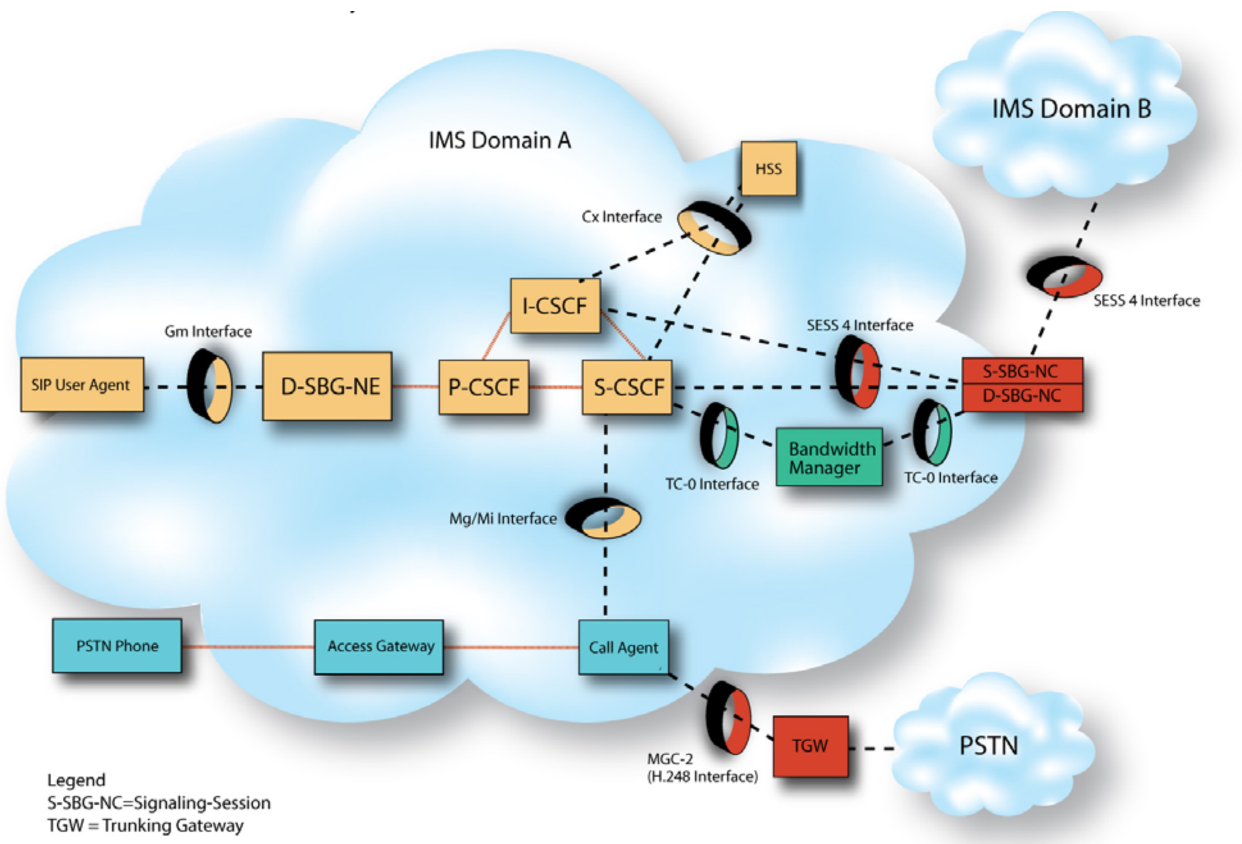
The Service Capability Interaction Manager (SCIM) orchestrates and assembles services (one of the advantages of IMS is that services can be pulled together from individual components that may reside on different platforms on a network).

The user's service profile is retrieved from the HSS via the Cx (S-CSCF) and Sh (SCIM) interfaces. The S-CSCF handles static service profiles whereas the SCIM handles the dynamic interaction of services and context dependent service profiles.

The ISC interface enables the S-CSCF to reach the Application Servers (and the SCIM) which in turn may connect to Media Servers. A Media Resource Broker function can be employed to optimize the allocation of Media Servers to sessions.

In the MSF R3 Architecture, the Media/Signaling Gateway is used to interwork between an IMS domain and the PTSN to support priority calling (maintain priority marking) when originated in either network. Scenario 2 also demonstrated the use of the SIP Resource Priority Header to trigger Call Admission Control (CAC) mechanisms to allow access to the IMS network for priority calls over nonpriority calls during network congestion.

Scenario 3: Interconnectivity between Two IMS Domains



Scenario 3 demonstrates an IMS interconnection between subscribers in the MSF R3 domain and a "pure'" IMS domain. In essence, MSF R3 and IMS appear as peer networks.

In addition to adding a second domain to this series of validations, this scenario also adds new functions and interfaces to the mix. The critical function, given that this scenario involves two IMS domains, is the Signaling Session Border Gateway-Network Core (S-SBG-NC) and the testing of the NNI between the IMS domains.

The S-SBG-NC serves as the point of contact for session signaling between service provider domains. Typically, it also performs topology hiding where required, negotiation of the security relationships among S-SBG-NCs, and controlling the network address translation (NAT)/firewall functions in its own domain. If necessary, the S-SBG-NC can also manage QoS for media flows and serve as an application-level gateway.

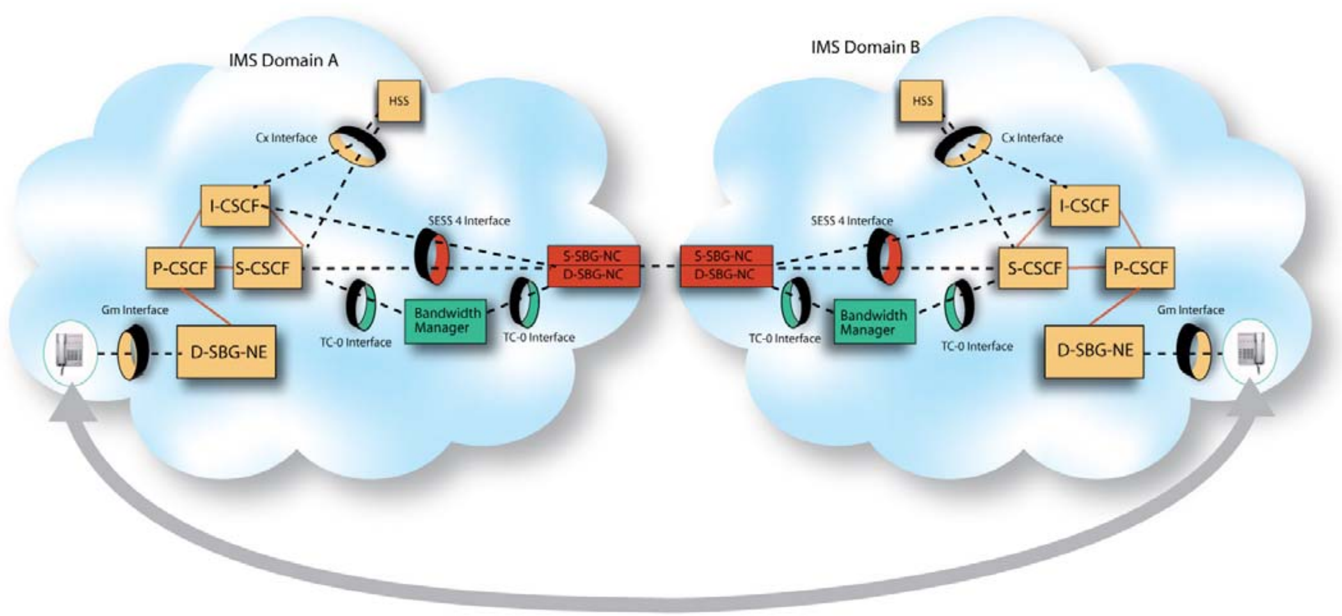
The S-SBG-NC uses the MSF SESS 4 interface to establish IMS call signaling to and from the CSC functions and between IMS networks.

When the S-CSCF passes a call destined for the PSTN to the call agent, the CA implements the Breakout Gateway Control Function (BGCF), routing the call to the circuit-switched public telephone network.

The Trunking Gateway (TGW) is used to establish a media path between an IMS domain and the PTSN. It was validated in 2004 and is a secondary focus of this scenario.

Scenario 3 evaluates a range of network interconnect options in a setting that simulates a commercial deployment. To complete each test case, a basic call must be made and a media path established in each direction.

Scenario 4: Roaming



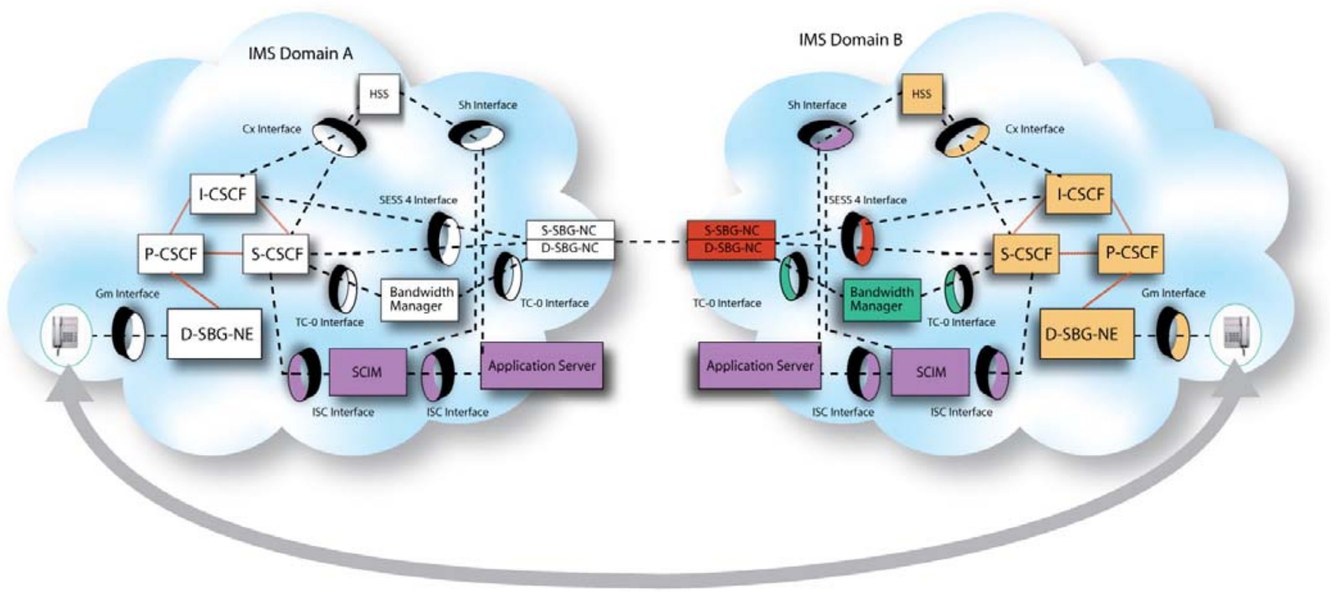
Scenario 4 focused on the roaming of IMS end-points between domains. IMS defines two “models” for how roaming is achieved. The Home GGSN model tunnels both the signalling and media back to the user’s home network, effectively treating the roamed-to network as an extended access network. The visited P-CSCF model allows a user to make use of a P-CSCF in the visited network, which in turn connects back to an S-CSCF in the user’s home network.

Scenario 4 tested the visited P-CSCF model because it readily permitted the enabling of end-to-end QoS and potentially permits the optimization of the routing of the media.

Since the visited and home networks represent separate administrative domains, pairs of S-SBG-NC and D-SBG-NC are deployed on the Network to Network Interfaces (one on the edge of each network). The SIP interface between the P-CSCF and I/S-CSCF (the Mw interface) therefore passed through a pair of SBGs.

Another aspect of roaming encompassed by Scenario 4 is the potential for optimal routing of the media between the end-points rather than to tunnel the media flows back through the home networks, while still maintaining end-to-end QoS. This is a future capability that can be tested in this scenario in coming GMI events.

Scenario 5: Roaming with Value-Added Services



The final scenario, Scenario 5, demonstrates the value added services of Scenario 2 accessed when the user has roamed to another network. The scenario demonstrates a user's ability to access his or her services when roaming (perform authentication, for example) and, in some circumstances, vary their service set depending upon the access network.

Since the user's session is still handled by an S-CSCF in his or her home network, the application interface (ISC) doesn't span network boundaries. However, it can still provide information on the current access network to the application entities.

Implementation Agreements Developed for GMI 2006

The following table lists the MSF IAs that were used throughout GMI 2006, as well as whether or not they were tested during each scenario.

Table 2: GMI 2006 Interoperability Agreements

Reference	***IA Title***					
		1a	**2**	**3**	**4**	**5**
MSF-IA-DIAMETER.001-FINAL	Implementation Agreement for Diameter interface to Bandwidth Manager	X	E	E	T	E
MSF-IA-DIAMETER.002-FINAL	Implementation Agreement for the DB-0 Interface	X	E	E	E	E
MSF-IA-DIAMETER.003-FINAL	Implementation Agreement for the DB-2 Interface	X	T	X	X	E

MSF-IA-MC.001v2-FINAL	Implementation Agreement for the 3GPP Mc Interface	T	X	X	X	X
MSF-IA-MEGACO.003.01-FINAL	H.248 Implementation Agreement between a Call Agent and an IP Trunking Gateway	X	X	T	X	X
MSF-IA-MEGACO.011-FINAL	Implementation Agreement for a MSFR3 MGC-2 Interface; H.248 Profile for Controlling Trunking Media Gateways	X	X	T	X	X
MSF-IA-MEGACO.010-FINAL	Multi Service Access Gateway Implementation Agreement (UK Market based on ETSI H.248 profile)	X	E	E	X	X
MSF-IA-MEGACO.009-FINAL	Implementation Agreement for H.248 interface to D-SBG	X	E	E	T	E
MSF-IA-MEGACO.014-FINAL	Implementation Agreement for explicit SIP signalling pinhole control via H.248	X	E	T	E	E
MSF-IA-SDP.002-FINAL	Implementation Agreement for SDP usage	X	E	T	E	E
MSF-IA-MGCP.001-FINAL	Implementation Agreement for MGCP Profile for Call Agent to User Agent Interface	X	E	E	X	X
MSF-IA-MGCP.002-FINAL	Implementation Agreement for MGCP IA Call Agent <-> User Agent Security Addendum	X	E	E	X	X
MSF-IA-SIP.002v2-FINAL	*Implementation Agreement for CORE SIP Profile for Voice over IP Version 2*	X	E	E	X	X
MSF-IA-SIP.012-FINAL	Implementation Agreement for MSFR3 SIP Server	X	E	T	T	E
MSF-IA-SIP.005-FINAL	*Implementation Agreement for SIP Interface between Call Agent and Service Broker*	X	E	X	X	E
MSF-IA-SIP.013-FINAL	Implementation Agreement for the (SIP) ISC interface	X	T	X	X	T
MSF-IA-SIP.014-FINAL	Media Resource Broker SIP Client Implementation Agreement	X	T	X	X	E
MSF-IA-SIP.015-FINAL	Implementation Agreement for SIP Media Server Interface	X	T	X	X	E
MSF-IA-PARLAY.003-FINAL	Implementation Agreement of Parlay/OSA API for GMI 2006	X	T	X	X	T

MSF-IA-PARLAY.004-FINAL	Implementation Agreement for Parlay X API for GMI 2006	X	T	X	X	T
MSF-IA-SNMP.001-FINAL	Implementation Agreement for Bandwidth Manager TC-2 Interface	X	E	T	E	E

Key
T = explicitly included in GMI test scenarios.
E = exercised (but not the subject of test scenarios)
X = not used
Italics indicate MSF R2 IA

Results and Recommendations

Within each GMI 2006 scenario, test engineers attempted to evaluate as many combinations of vendor equipment for interoperability as possible. The following table provides details for each scenario. Overall, over two thirds of possible test scenarios were successfully completed.

Table 3: Test Cases Completed Successfully

Scenario	Total Test Cases	Successfully Completed Test Cases	Percent Completed
Scenario 1	25	18	72
Scenario 2	33	21	64
Scenario 3	7	5	71
Scenario 4	9	6	71
Scenario 5	22	15	68

Scenario 1: Single Domain with Roaming ("Nomadic") User

Scenario 1 serves the base scenario for GMI 2006; all other scenarios build on it. Table X lists the basic components and functions used in this scenario.

Table 4: Components and Functions Employed in Scenario 1	
AGW	Access Gateway
BM	Bandwidth Manager (Resource and Admission Control)
CA	Call Agent
D-SBG-NE	Network Edge Session Border Controller-Data/Media Component
HSS	Home Subscriber Server
I-CSCF	Interrogating Call Session Controller
P-CSCF	Proxy Call Session Controller
SIP UA	SIP User Agent
S-CSCF	Serving Call Session Controller
S-SBG-NE	Network Edge Session Border Controller-Signaling Component

Table 5: Interfaces Validated in Scenario 1	
Cx	Communicates between S-CSCF/I-CSCF and the HSS

Gq	Communicates between session control (P-CSCF or CA) and BM to reserve bandwidth
Mg	Passes calls from PSTN end points into the IMS network
Mj	Passes calls from the IMS network to the call agent serving the target PSTN end points
Mw	Exchanges information between CSCFs

Table 6: Issues Observed During Scenario 1 Testing	
Equipment shortfall	Equipment shortages at some sites meant many test cases could not be validated locally.
SIP URI Interoperability	At one site the SBG supported the SIP URI where the host part was an IP address, while the CSC required a fqdn SIP URI. Vendor engineers modified the code so that it supported the fqdn SIP URI to support testing between the SBG and CSC.
H.248	No P-CSCF implemented the H.248 interface used to directly control the D-SBG-NE. As a result the D-SBG-NEs were eliminated from all tests that use this interface in their call flows. It was noted that vendors may have assumed the presence of a function such as the ETSI TISPAN SPDF, which is an intermediate network element, between the P-CSCF and D-SBG-NEs. This issue was compounded by a related problem. Specifically, many Session Border Gateways combined both the S-SBG and D-SBG functions in a single element, and therefore did not support the open interface between the S-SBG-NE and the D-SBG-NE. As a result, only limited testing could have been completed according to the architecture, even if the P-CSCF vendors had implemented the H.248 interface specified to communicate with the D-SBG-NE. If the open interface between the S-SBG-NE and the D-SBG-NE is not widely supported, this will create problems for the ETSI TISPAN architecture as well. The MSF will re-assess industry trends in this area and may revise the architecture and appropriate Implementation Agreements accordingly.
IMS UA	Several participants supplied proprietary IMS UAs. In one case, this component generally worked with other vendors' products. Other proprietary IMS UAs worked only with products provided by their vendors, which is

	the setup used for test cases.
	Two test tool vendors modified their software to simulate compatibility with the proprietary products. This required them to constantly change the code to work with different vendors' products.
	Finally, the simulators were less than 100 percent stable; in most cases, they worked with authentication disabled. Without an open IMS UA this site may have missed some errors while executing test cases.
Ghost Ring	During testing, it became apparent that Call Session Control elements in some circumstances forwarded the SIP signaling to the recipient phone even when the Bandwidth Manager indicated there was insufficient bandwidth available for the call. This resulted in "ghost" rings. The hypothesis is that UE and session control element vendors have not consistently implemented RFC 3312, which makes this a resource management and SIP signaling implementation issue. This issue was not resolved during GMI 2006.
SUBSCRIBE	One of the SBG participants at a host site did not support SUBSCRIBE; this led to a failure when it was tested with a UE that supported SUBSCRIBE.
Request URI INVITE	An SBG at one site rewrote a terminal's INVITE, stripping off the route header. The CSC does not accept this format and replied with a "403 Forbidden" message.

Scenario 2: Single IMS Domain with Roaming Subscriber and Value-Added Services

Table 7: Components and Functions Added to Scenario 2	
Application server	
MRB	Media resource broker
Media server	
SCIM	Service Capability Interaction Manager

Table 8: Interfaces Validated in Scenario 2	
ISC	Enables the SCIM and application server to reach the S-CSCF
Sh	Enables HSS, SCIM, and application servers to exchange subscriber profiles, service parameters, and QoS for a specific application

Table 9: Issues Observed During Scenario 2 Testing	
TEL URL	The SIP stack of the ParlayX GW at the one host site treated the TEL URL as an absolute URI, which is defined in RFC 3261. The issue was resolved by modifying the parsing routine in the SIP stack.
Session teardown	The ParlayX GW at one site only recognized one record-route parameter, even though multiple record-route parameters were present, because they had the same IP addresses. As a result the S-CSCF could not tear down the session properly. The issue was resolved.
Call Agent	Only a limited number of vendors provided a call agent(SoftSwitch). Consequently, interworking between the Call Agent and IMS infrastructure was tested relatively few times. Although the tests were successful where equipment was available to do the testing, it was generally felt that more extensive testing would have provided better validation of the IAs.
Priority Call	In some tests of priority calling using video, the clients had to be rebooted to make them work.
PRACK request	One of the IMS core participants did not support and thus did not respond to a PRACK request from the AS, which is required to wait for the PRACK response before establishing a session. The workaround was for the AS not to send a PRACK to the IMS core participant.
ACK	Traces revealed that an AS did not correctly respond to the ACK message from the IMS core participant because the TOP VIA in the message did not contain the mandatory branch parameter. No workaround was discovered because this diagnosis was made only after testing was finished.

Scenario 3: Interconnectivity between Two IMS Domains

Table 10: Components and Functions Added to Scenario 3	
BGCF	Breakout Gateway Control Function
S-SBG-NC	Signaling Session Border Gateway-Network Core
TGW	Trunking Gateway

Table 11: Interfaces Validated in Scenario 3

MSF SESS 4	Establish IMS call signaling between IMS networks

Table 12: Issues Observed During Scenario 3 Testing	
Video Codec	What was assumed to be a codec problem affected the quality of the video transmissions between videophones at two host sites. Both sites attempted to debug, but the issue was not resolved.

Scenario 4: Two IMS Domains with Roaming Subscriber
No components, functions, or interfaces were added to Scenario 4.

Table 13 Issues Discovered During Scenario 4 Testing	
Authorization error	One test case failed because of an authorization error between host sites. Only one site was able to register with the other. This issue was not resolved.
Stripped path header	During the roaming test cases, some S-SBG-NCs stripped off the path header in the SIP message. As a result, the I-CSCF rejected the request (by sending a 500 message). The S-SBG-NC was patched during GMI 2006, which fixed the problem.
PRF and PF implementation	None of the vendors had implemented PRF and PF, SIP header fields proposed within the MSF to allow media route optimization. Thus the roaming tests involving "Optimal Media Routing" could not be successfully executed.

Scenario 5: Two IMS Domains with Roaming Subscriber and Value-Added Services Topology

No new components, functions, or interfaces were added to Scenario 5. This scenario combined the value added services components from scenario 3, with the network interconnection tested in Scenario 4.

Table 14: Issues Discovered During Scenario 5	
Buffer overflow	One of the test cases failed because the Route header field got too long for the buffer allocated for it in one of the nodes along the path. This problem appeared in this scenario because it had the longest paths, and therefore the longest Route header field. However, in practice, this will not be an unusual situation. MSF IAs will be updated to specify realistic minimum buffer sizes.

Conclusions

Some have said that IMS is too large and too complex, to ever reach wide-scale commercial deployment. GMI 2006 has clearly shown this is not the case, and that the reality of deployable, carrier-grade IMS is much closer than the skeptics claim. With no more than straightforward setup, much of the equipment was up and running, in multivendor configurations, within a matter of hours. This was especially true of the core IMS, where effective multivendor interoperability was the norm. Even complex advanced services functionality, such as interworking of priority Emergency Telecommunications Service (ETS) calls between PSTN and IMS domains, was successfully demonstrated. IMS isn't quite at the "plug and play" stage yet, but it is certainly on a par with much of the existing telecom equipment.

This does not mean that everything worked exactly as specified in all configurations. There were problems and issues were identified in GMI 2006. Many of the problems were simply implementation errors by a vendor. GMI provided these vendors with valuable engineering input.

In other cases the root causes were less clear. In these instances, detailed call traces were collected, and have been analyzed by the MSF technical committees. Where necessary, concrete action plans have been drawn up and the technical committees are now executing these plans. Their actions depend on the specific problems. For example, changes to MSF Implementation Agreements are being considered. Where appropriate, feedback is being provided to the SDO responsible for the effected standards. As the MSF continues to work through these issues, the interoperability of IMS will be greatly improved.

This is a key point worth considering in more detail. The number of issues is not as important as the type. The issues uncovered in GMI 2006 were inherently addressable, and feedback from GMI is exactly the input needed to do this. It is important to bear this in mind when examining the technical details. The technical issues are not suggestive of an overly complex system. Rather, they are consistent with input to fine-tune an essentially sound, mature architecture. With that in mind, it is worth briefly reviewing a few of key technical conclusions from GMI.

- The "preconditions" mechanism for end-to-end QoS is not being consistently implemented by the industry. Current mechanisms, based on RFC 3312, have been specified in standards but are not being widely or consistently implemented. The MSF will produce a white paper describing how this problem was manifested during GMI and use this to provide input to the relevant standards bodies.

- No P-CSCF had implemented the MSF specified H.248 interface to directly control the D-SBG-NE. Presumably this was based on the assumption that an intermediary function would be present, such as the Service Policy Decision Function (SPDF) of the ETSI TISPAN R1 architecture. In addition, many Session Border Gateways combined both the S-SBG and D-SBG functions in a single element, and did not expose the MSF-defined interface between these two elements. The MSF will reassess industry trends in this area and may revise the architecture and appropriate Implementation Agreements accordingly.

- There was a disappointing shortage of true IMS terminals, and much of the testing was done on SIP end-points. It seems likely that the IMS terminals may still be in the prototype stage, but the MSF considers that the industry missed a useful opportunity to put them to the trial. However, even here, there was a silver lining. GMI participants were encouraged that it was possible to demonstrate significant functionality even with "plain vanilla" SIP end-points.

- Authentication was one area where the problem was not a lack of standards, but rather too many—and too many options within those standards. Once the various configuration options were sorted, authentication worked as intended, but the configuration was complex and time-consuming. Clearly it is not realistic to expect the average user to deal with the current complexity. This seems to be a problem ideally suited to an IA, and the MSF is evaluating the possibility of a new IA addressing authentication/authorization profiles.

- In practice, SBGs come in two configurations. One variant focuses on the User Network Interface (UNI) and deals with the issues associated with user access to the network. The other focuses on the Network-to-Network Interface (NNI) for interconnection between networks. When deployed at the NNI to support roaming, the SBG is effectively a hybrid UNI/NNI, when a user is accessing the network across an interface between networks. As a result, some problems were encountered in the roaming scenarios, and the MSF has launched a work program to address this in a new IA.

- No vendor fully supported the ability to provide optimal routing of the media in the GMI roaming scenarios. Rather, the media followed the SIP signaling back through the home networks. In some cases this resulted in the media taking a significantly longer path than was, strictly speaking, necessary, with a resulting QoS degradation. The MSF will liaise with appropriate industry bodies to address this issue.

These are important technical issues, and the feedback from GMI will be valuable in resolving them. Nevertheless, as stated earlier, they are not so much a cause for concern but rather indicate a system approaching maturity. GMI 2006 has shown clearly that this is the current state of IMS. Interoperability events like GMI will be the thing that continues to improve IMS to achieve full maturity.